THURSDAY, NOVEMBER 28, 1872

FERMENTATION AND PUTREFACTION*

IT is one of the great attractions of the science of Botany, an attraction common to all the other branches of the study of Nature, that wherever we may happen to be, and under whatever circumstances, something interesting and suggestive is continually brought before the eye and mind educated to understand its teachings, and no true naturalist ought long to be in a difficulty seeking for a suitable subject for illustration. At this season of dearth of flowers I hold in my hand a basket of "Duchesse" pears. These have, after their kind, been plucked in France before they were ripe, and some few of them are hard, green, and flavourless; others are soft, full, and mellow, with a rich, delicate aroma—morsels fit for the gods—while others have gone too far, and show the

> —"little pitted speck on garner'd fruit,
> That rotting inward slowly moulders all."

If you will allow me, I will, during the few minutes still at my disposal, give you a brief sketch of what has been done of late towards the explanation of the two phenomena which are for the moment the most prominent in connection with these pears, their ripening, and their decay.

These changes depend upon *fermentation* and *putrefaction*, two processes which are very familiar, and which have of late engaged the attention of some of the most able and skilful men of science, both on account of their vast importance in the economy of nature and of art, and of the singular phenomena which accompany them. These phenomena are very complex and difficult; but chiefly through the patient researches of botanists such as De Bary on the one hand, and of chemists and physiologists who may be represented by Pasteur, Lister, Burdon Sanderson, and Hartley on the other—steady progress is undoubtedly being made towards their solution, although much still remains obscure.

The character which most broadly distinguishes the vegetable from the animal kingdom is certainly the power which the former possesses when taken in mass of winning over from the inorganic kingdom binary compounds which cannot contribute directly to the nutrition of animals, decomposing them, and re-combining their elements into organic compounds suitable for the support of animal life. This process—the decomposition of water into oxygen and hydrogen, of carbon dioxide into carbon and oxygen, and of ammonia into hydrogen and nitrogen, and the re-combination of these four elements while in a nascent condition into starch, sugar, gum, protoplasm, &c.—is, so far as we know, carried on in plant-cells containing endochrome under the influence of light, and in such cells and under such circumstances alone. We thus find that this truly vegetable process is performed by a very small portion of an ordinary plant. The cells of the internal organs of plants and of large pulpy masses, such as these pears, connected with the function of reproduction, are perfectly colourless; simple sacs of cellulose, containing in their early condition protoplasm, and increasing and multiplying by its agency; and afterwards containing other substances in addition, such as starch and sugar, the products of its assimilation and excretion. These masses of protoplasm with their investing membranes composing the so-called "cells" of the pear, feed, indeed, upon the ternary and more complex compounds produced by the leaves of the pear tree, and are aërated by the fluids which are passing through the tissues of the pear tree; but, secluded from the light, and developing no special colouring matter, their reactions are not in the strict sense "vegetable;" they absorb the organic compounds and breathe the distributed air in the true animal sense, just as *Amœbæ* would do. To take the function of respiration as a test, they absorb oxygen and exhale carbon dioxide, while in the green parts of plants, which alone perform the great function of the vegetable kingdom in keeping up the "balance of organic nature," the exhalation of carbonic acid is in the sunshine entirely masked by the exhalation of oxygen—the product of its decomposition. A green tree may be likened to that wonderful animated tree, one of the oceanic Siphonophora, where a certain set only of the polyps are set aside to feed and to supply nutrition for the whole, while others, identical with these in essential structure, feel, or sting, or reproduce the species, or palpitate through the water as locomotive swimming-bells.

It is, perhaps, not easy at once to realise this difference in the vital relations of the different parts of the same plant, but it becomes clear enough in the case of pale parasites, for example *Cuscuta*. The dodder possesses no endochrome cells of its own; it feeds like an animal upon the organic compounds elaborated by its host. It contributes in no way as a vegetable to the balance of organic nature, and yet it is evidently a plant nearly allied to the ordinary bird-weeds, with all the characters of their well-known natural order.

These "Duchesse" pears are separated from the tree. They were probably separated physiologically before they were taken off, for before we would consider them fully ripe a certain shrivelling takes place in the cells and vessels of the fruit-stalk at a kind of joint, and the communication between the pears and the tree is at first partially and then entirely interrupted. But the pear does not die; it hangs out in the sunshine, and certain chemical changes take place within it, still under the guidance of vital action, sweetening it and developing its flavour. We learn from the beautiful researches of M. Bérard that if fruit be placed to ripen in air or in oxygen gas, a considerable quantity of oxygen is absorbed and an equivalent proportion of carbon dioxide is given off; that, in fact, a notable quantity of oxygen is burned in a true process of respiration. It is calculated by De Bary that the number of plants in which chlorophyll is absent—that is to say, which have no power of decomposing and re-combining the elements of water, carbon dioxide, and ammonia, and which consequently require to have their food presented to them in the form of organic matter—is fully equal to that of green plants, say 150,000. These plants are chiefly fungi. The part they play in the economy of the organic world is wonderful. The moment a plant gets worsted in the battle of life, becomes delicate from uncongenial soil or other circumstances, or gets smothered by a more vigorous rival, they set upon it and burn it.

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* From the Opening Address for the Session 1872-73 to the Botanical Society of Edinburgh, delivered on Nov. 14, by Prof. Wyville Thomson, F R S., President of the Society.

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If we look just now in the Botanic Garden at any of the old summer beds of half-hardy plants, we shall see them shrouded in a maze and network of white fleecy mould. That mould is a fungus finishing the work of extermination which the frost has begun, and then burning the bodies. In all the odd corners there are heaps of rotting vegetation. These stems and leaves are not rotting of themselves; heat them to 212° F., so as to kill the seeds of the fungi, and seal them up in closed cases, and although they will slowly decompose, they will never rot. They are being burned by the process of respiration of fungi just as effectually as they would be if they were collected into a heap, dried, and set fire to. Most of these fungi are very minute, but each of them, when it is found in anything like a well-developed condition, is thoroughly characteristic. Still they are so small and so simple that it is difficult to distinguish parts of those organs whose form is not strongly marked.

I will give a brief sketch of the life-histories of one or two of these fungi, and the first I will choose is a well-known mildew, *Mucor stolonifer*. This species is often found on juicy fruits, covering them with white woolly patches scattered over with small black heads, and producing a very rapid putrefaction beneath the surface of the fruit. A number of delicate branching filaments form a rich network in the substance of the fruit, filaments which are easily distinguished from those of some nearly-allied forms by their long simple tubes without partitions. These delicate filamentous tubes, which are the parts first to appear, and form the basis, as it were, of the fungus, are called the *mycelium*, and are found in almost all fungi. From the mycelium, at certain points, long rather wide tubes start from the surface on which the fungus is growing obliquely into the air, and, after running along for a time, again dip down and give origin to other tufts of mycelium tube-roots. At the point where these roots come off, as at the bud of a strawberry-runner, a little tuft of tubular stems rises up vertically, and ends in round vesicles which at first are entirely filled with transparent protoplasm. These are cut off from the stem by a partition which is at first flat, but afterwards assumes an arched form, giving the space between it and the outer wall the shape of a very deep meniscus. The protoplasm in the space ultimately breaks up into a mass of black polygonal spores, which escape by the giving way of the outer wall of the sporangium. These spores are thus produced by no process of true reproduction, but are simply separated particles of the protoplasm of the parent plant. In hot summer weather, chiefly on the surface of sour fruit, *Mucor stolonifer* forms thick patches, with broad stolons, and from these, twigs spread over the surface of the fruit. When two of these twigs meet one another they form large vesicular expansions, and then apply themselves to one another. A diaphragm is formed across each of the vesicles, thus cutting off the distal end of the vesicle, which is filled with protoplasm. The double wall between the two cells gives way, and the protoplasm in the two unites, as in the union of the cell-contents in the conjugation of *Zygnema*. These "coupling cells" have thus become fused into a single cell called a *zygospore*, which goes on enlarging, and is covered with a thick skin.

The simple spores, when scattered on moist ground, send out filamentous shoots of mycelium, which in their turn originate stolons as before; but the zygospores do not produce mycelial filaments when they germinate, but form one or two sporangium-bearers directly at the expense of the substance of the zygospore, and the ordinary course of growth is resumed from their spores. There are thus two modes of multiplication in *Mucor*—one by sporangia and spores, non-sexual, a simple method of propagation by buds—the other a true reproductive process, by the conjugation of male and female elements. It seems to be only occasionally and under specially favourable circumstances that the latter process occurs, and this mildew often goes on reproducing itself by spores alone for many generations.

The life history of *Mucor mucedo*, one of the commonest of the mildews, is not yet thoroughly known. Here the cells are again simple and undivided, but each sporangium-bearer usually ends in several large sporangia. Under certain circumstances this sporangium-bearer sends out tufts of finely dividing twigs, each of which ends in a small sporangium, which, to distinguish it from the larger form, has been called a sporangiolum. At other times processes are produced from the main cells which rise into delicate tubular branches, and give off globular cells which are called *conidia*—simple external spores, differing entirely in their character from the spores produced in sporangia; and if this mould be grown in a solution in which it is fairly nourished without a full supply of oxygen gas, long fibres are produced which break up into a multitude of separate bead-like cells filled with protoplasm, and capable of reproducing the organism. WYVILLE THOMSON

(*To be continued.*)

EXPLORATION OF THE SOUTH POLAR REGIONS

II.

WHILE Balleny was making the discoveries to which we alluded at the close of the previous article, two other expeditions were actively pursuing their researches and extending our knowledge of the Antarctic regions,—a French expedition under Dumont d'Urville and an American under Lieutenant Wilkes. Neither expedition was originally intended for South Polar exploration, and to this among other reasons is it to be ascribed that the results, with respect to the exploration of the South Polar regions, are of but little value compared with those obtained by the almost contemporaneous English expedition.

From the South Shetlands D'Urville directed his course to the south, and discovered on February 27, 1838, in 63° 10′ S. lat. and 57° 5′ W. long., a coast which bears the name of Louis Philippe Land, and rises to a height of between 2,000 and 3,000 feet above the sea. The general outlines of this coast were already indicated on Weddell's chart.

Two years later we find the same explorer again active, and with a better result. In January 1840 he left Tasmania for the south, steering for the region between 120° and 160° E. long. On January 19, in 66° S. lat., he found land from 2,000 to 3,000 ft. high, entirely covered with snow and ice. On the 21st some of the sailors landed on a little island consisting of gneiss, which D'Urville named Adelie Land. On the 30th and 31st D'Urville sailed

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